PIER Energy-Related Environmental Research
Environmental Impacts of Energy Generation, Distribution and Use

Evaluation of Alternative Models and Methods for Prediction of Hydropower Resources in California and the Pacific Northwest

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Contractor: University of Washington, Department of Civil and Environmental Engineering
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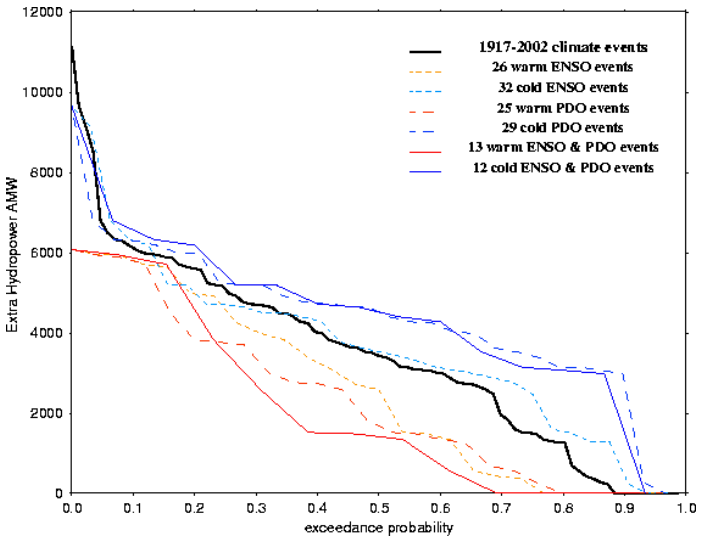
The Issue

Hydropower from California and the Pacific Northwest is an important component of the energy mix supplying electricity to California. Recent research has demonstrated that surplus hydropower resources from the Pacific Northwest are predictable with long lead times (several months to a year or longer) via long-range forecasts of ENSO and PDO[1] (see figure). If these new findings are to be used effectively in a management context, it is necessary to evaluate the decision support tools needed to provide real-time forecasts of these hydropower resources.

In addition, the California Energy Commission is interested in developing a set of integrated

Probability of Exceedance for Spring Surplus Energy Resources in the PNW



Retrospective CDFs (cumulative probability distribution functions) of spring surplus hydropower resources in the Pacific Northwest as a function of ENSO and PDO categories.[1]
Source: Voisin et al.[2]

[1] ENSO, the El Niño Southern Oscillation, is a recurring pattern of ocean-atmospheric interactions associated with the east/west location of warm sea surface temperatures in the tropical Pacific Ocean. PDO, the Pacific Decadal Oscillation, can be thought of as the low-frequency expression of El Niño in the North Pacific. The two phenomena have strong effects on winter climate in the western U.S. When ENSO and PDO are in their warm phase, for example, the Pacific Northwest is typically warmer and drier than normal in winter, resulting in lower surplus hydropower production in the spring.

[2] Voisin, N., A. F. Hamlet, L. P. Graham, D. W. Pierce, T. P. Barnett, and D. P. Lettenmaier. 2006. The role of climate forecasts in western U.S. power planning. *Journal of Applied Meteorology* 45 (5): 653–673.

decision support tools for estimating hydropower resources in California. To achieve this, more information is required about the performance of alternative predictive models and methods, and the resources necessary to implement, use, and maintain these tools.

Project Description

Several different computer models are currently available for simulating hydropower production in California and the Pacific Northwest. Each of these has been designed with different priorities and purposes in mind, and each has different performance characteristics and practical issues associated with its use. To date, these models have not been carefully evaluated and compared in the context of hydropower prediction. Such comparisons are important in that they provide a quantitative foundation for a well-informed choice of appropriate simulation tools that could be used in building new decision support systems.

To address this need, this project will compare six hydropower simulation models (three for California, three for the Pacific Northwest) representing three different levels of complexity and ease of implementation. The models to be examined will range in complexity from regression models that relate past hydropower generation to physical variables, to research models and operational models that represent the physical details of reservoir systems and associated hydropower generation with increasing detail. At the lowest level of complexity, two new regression models will be constructed by the project team; these will relate streamflow and reservoir storage to past recorded hydropower production for California and the Pacific Northwest. The two research models (ColSim and CVMod) and two operational models (GENESYS and CalSim II) to be compared already exist in the public domain (at least to the level of compiled computer code).

The models will be evaluated in terms of their ability to simulate observed hydropower production and reservoir storage in California and the Pacific Northwest over an appropriate retrospective period in both simulation mode (six models) and forecast mode (four models). At the completion of the study, five of the six models evaluated (all but CalSim II), along with the study results and database, will be archived on the Web and available to the Energy Commission for further evaluation.

PIER Program Objectives and Anticipated Benefits for California

This project offers numerous benefits and meets the following PIER program objectives:

- **Providing reliable energy.** This project will contribute to improved decision support tools to help energy planners meet California's power needs. Specifically, retrospective simulations and forecasts of hydropower resources have important applications for:
  - Evaluating the effects of climate variability and climate change on available energy resources
  - Predicting natural gas usage in California
  - Analyzing energy marketing decisions and long-term contracts
  - Making capacity-related decisions such as the timing of system repairs or maintenance
- **Providing environmentally sound and affordable electricity.** Hydropower is a clean, renewable energy source; moreover, it is ideally suited to supplying peak power needs and is usually much cheaper than replacement peaking energy generated using natural gas turbines

or other fuel-based technologies. This project will facilitate better use of the region's hydropower resources.

Final Report

PIER-EA staff intend to post the final report on the Energy Commission website in fall 2007 and will list the website link here.

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